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ON A
NORMAL RESISTANCE THERMOMETER.*

[A letter addressed by Mr. Robert Sabine, C.E., to Mr. Culley, Engineer-in-Chief of the P. O. Telegraphs.]

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I have to acknowledge the receipt of your letter with reference to the subject of thermometers for the purpose of measuring the temperatures of various parts of the pumps, ducts, and containers of the new extension of your pneumatic lines.

The system which I am of opinion you will find to give the most accurate results, with the least trouble, is that of a form of resistance thermometer modified in such a way as to obtain direct readings of temperature without having to make reductions.

Mr. C. W. Siemens, whose name is in so distinguished a manner associated with this subject, has proposed several very beautiful forms of resistance thermometers, with which I have had a good deal of experience. They are, however, not *normal* instruments; but as hitherto constructed they are *secondary* apparatus, depending upon readings taken directly from mercury thermometers, or upon coefficients determined originally by means of mercury thermometers: they in fact hold, in relation to mercury thermometers, only the same position which aneroids do to mercury barometers; whatever errors are incidental to the one being necessarily reproduced by the other.

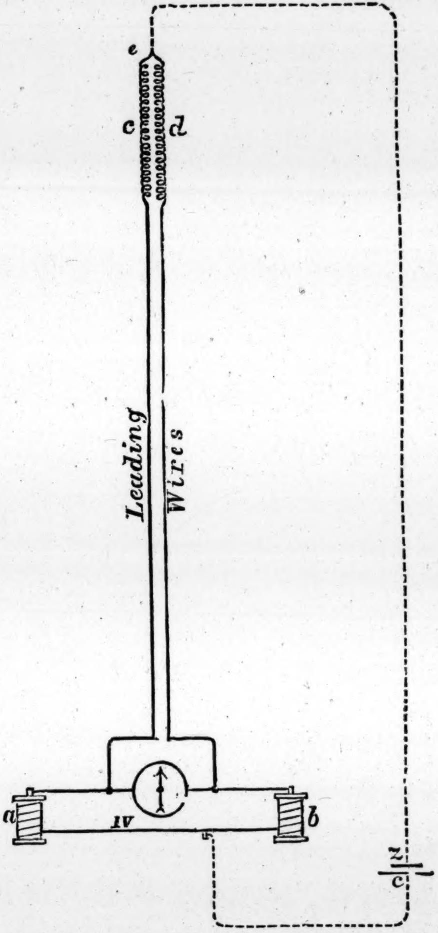
It appears to me that an electric resistance thermometer, in order to be a normal physical instrument, would have to fulfil all the following conditions:—

1. Its graduation must be *independent*; that is to say, be done without the help of any other thermometer,—in fact as if no other thermometer had ever existed.
2. The readings of temperatures must be direct, and free from any reference to the coefficients of the metals used in its construction.
3. Its indications must be totally unaffected by the temperature of the measuring apparatus.

I have recently subjected to a series of experiments a plan by which all these conditions may be easily obtained, and have succeeded in producing a resistance thermometer independent of the coefficients of its constituent metals, and infinitely more delicate and exact than any thermometer constructed of glass and mercury can be. This modification is as follows:—

Instead of making the thermometer coil of a single metal to form one side of the Wheatstone balance, and forming the other three sides by three resistances of the measuring apparatus, as has hitherto been done when using the balance, I put half the balance into the thermometer, and keep the other half only in the testing-room, by which arrangement the effect of temperature of the measuring apparatus is entirely eliminated. The half of the balance forming the thermometer I make (1) of a metal having a high coefficient, and (2) of an alloy having a low coefficient of increment of resistance with temperature. In making up this thermometer I take two lengths of wire, *c* and *d*, whose resistances are nearly equal, and wind them together upon a common spool, connecting their ends together, in the point *e*, with an earth or return circuit containing a battery and key. The other ends of the wires are connected to insulated leads, whose resistance is made inappreciably small in comparison with that of the coils.

Fig. 1.



The measuring apparatus consists simply of a bisected wire. In order to render thermometric readings with it convenient, I coil up its two ends on spools. The middle portion, *w* (on which the readings are taken), is provided with a scale and a travelling (bisecting) contact; the end portion, on *a*, is about 3¾ times as long, and the portion *b* about 3 times as long as *w*. With this relation, supposing the coil *c* to be made of a pure metal, and *d* of German silver or platinum-silver (the resistances of *c* and *d* being nearly equal at the mean temperature of the air), the bisecting contact on *w* will stand a short distance from one end, in order to balance the galvanometer needle, when the thermometer is placed in melting ice, and a short distance from the other end when it is in boiling water.

These two points on the scale being exactly noted, it is only necessary to subdivide the space between them into 100 equal parts, in order to have an independent centigrade thermometer; each degree of which shows the point where the bisecting contact must stand in order to balance the galvanometer when the coils *c* and *d* have the corresponding temperature.

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* Communicated by the Author.

The materials which I prefer for the construction of this thermometer are—

1. A pure metal, or a commercial metal as nearly pure as can be had, in order that its resistance may increase as much as possible with heat.
2. An alloy whose resistance increases as little as possible with heat.

I do not consider copper so good a metal as platinum to make thermometers of, because, whilst its percentage increment is nearly the same, its conducting power is so much higher that a larger mass of the metal is necessary, which may, to some extent, prevent it responding quickly to small changes of temperature. For the second coil of the thermometer, Matthiessen's alloy of platinum and silver is well adapted, because its percentage increment is very low, it has a low conducting power, and is very constant.

In order that this resistance-thermometer be an exact measure of temperature, it is necessary that the curves of the metal and alloy *separate uniformly;* that is to say, the percentage increment of the platinum at t° must be in the same proportion to that at 100° as the percentage increment of the alloy at t° is to that at 100°.

The formula for the conducting power of commercial platinum given by Matthiessen* is—

$$\lambda=11{\cdot}708-0{\cdot}031875t+0{\cdot}00006762t^{2},$$

and that for his platinum-silver alloy† is—

$$\lambda=6{\cdot}7032-0{\cdot}0022167t=6{\cdot}000001394t^{2}.$$

Now when a resistance-thermometer is constructed according to my method, with two coils (commercial platinum and platinum-silver alloy) wound together), and each having 1000 ohms resistance when at 0° C., their conducting powers and resistances at different points of the thermometric scale (assuming Matthiessen's figures to be correct) are as follows;—

	Platinum.		
Temp. Cels.	λ.	Resistance.	Increment per cent.
0°	11·708	1000·0.	—
25°	10·953	1068·9	6·89
50°	10·283	1141·2	14·12
75°	9·698	1207·3	20·73
100°	9·197	1273·1	27·31

	Platinum-silver Alloy.		
Temp. Cels.	λ.	Resistance.	Increment per cent.
0°	6·7032	1000·0	—
25°	6·6487	1008·2	0·82
50°	6·5951	1016·3	1·62
75°	6·5448	1024·2	2·42
100°	6·4954	1032·0	3·20

The curve of the metal is evidently much steeper than that of the alloy, but it is similar in its nature, or very nearly so, according to the above formulæ, as will be seen by the following table, col. 2 of which gives the resistances of the alloy calculated by Matthiessen's formula, and col. 3 the resistances of the alloy calculated from those of the platinum coil, supposing the curves of the two to separate uniformly.

	Calculated Resistance of Alloy.		
Temp. Cels.	By Matthiessen's Formula.	From Platinum Formula.	Difference per cent.
0°	1000·0	1000·0	—
25°	1008·2	1008·1	0·01
50°	1016·3	1016·5	0·02
75°	1024·2	1024·3	0·01
100°	1032·0	1032·0	—

The greatest difference between these two curves is in the middle (about 50°), where it amounts to very nearly 0·02 per cent. Now as an increase of 100° makes a difference of about 24 per cent between the resistances, a difference of 0·02 per cent will occasion a discrepancy of only about 0·08 degree centigrade. But as each of Matthiessen's curves was determined from only three temperatures [the platinum at 9°, 54·5°, and 100°, and the alloy at 8·27°, 54°, and 99·9°], I do not think that they are likely to be exact within this limit.

Whether this discrepancy is due to an error to this extent in Matthiessen's formulæ, or to any real difference in the nature of the curves for the metal and alloy, remains to be determined. It is, however, clear that within this limit of error a differential resistance thermometer may be made and independently graduated without any direct or indirect aid from any other thermometer, and therefore that it may be to this extent considered a normal instrument. And it has this decided advantage, that the values of neither the resistances nor the coefficients of its constituent metals are required to be known.

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ROBERT SABINE.

ON THE

EFFECTS PRODUCED BY ELECTRIC CURRENTS ON MERCURY IMMERSED IN DIFFERENT SOLUTIONS.

By M. TH. DU MONCEL.

MR. HUGHES has shown that if we immerse in ordinary water some drops of mercury, this metal dilates under the influence of the passage of the electric current, when the circuit is formed by the intervention of a stratum of water. I have made some experiments of this character, and I append the results. If we study the movements of mercury in solutions of several natures, we perceive that the direction of impulsion* varies according to the quantity of gas which is disengaged at one or other of the electrodes, and the movement is effected towards the electrode which disengages the least. Also, with ordinary water the movement is towards the positive pole. With solutions of sulphate of copper, sulphate of iron, bichromate of potash, sulphate of mercury, &c., in which hydrogen is largely absorbed in the reduction of the salt, the movement is effected towards the negative pole. Nevertheless the more or less perfect conductibility of the solution takes part in the phenomena, and we can test this by taking rain-water, spring-water, and water acidulated with sulphuric acid. With the two first liquids motion is effected in the same direction, but it is more characterised in one case than in the other, by reason of the differences in intensity of the electric current traversing them. With the acidulated solution the movement becomes imperceptible and often in a contrary direction to that which obtained with pure water, because the disengagement of gas at the two electrodes was effected in nearly the same proportion. If we employ solutions capable of disengaging at the positive pole a gas susceptible of energetic combination with hydrogen, when in the nascent state, as occurs with solutions of chloride of sodium, cyanide of potassium, furnishing chloride and cyanogen at the positive electrode, the effects, as to the movements of the mercury, are rather capricious, and manifest themselves generally (after the mercury has constituted for some instants the negative electrode) in a direction similar to that produced with water. Also, if we pass, during a short time, the current from a battery of eight Chutaux elements through a solution of chloride of sodium, at the centre of which we immerse a drop of mercury put into connection with the negative pole of the battery, and if, having broken this circuit, we plunge into the mercury the positive electrode at which the chlorine is disengaged, an abundant liberation of gas, even more energetic than that which resulted from the action of the battery, is produced at the point of contact of the electrode with the mercury, and during a comparatively long time. If, during this liberation, we plunge the negative electrode into the salt water, the surface of the mercury is immediately covered with a yellow pellicule which passes rapidly to black, and which appears to be the suboxide or protoxide of mercury; but as soon as this film is formed the disengagement of gas ceases, and it is only when the negative electrode is withdrawn, and some instants after the pellicule has disappeared, that the disengagement of gas recommences. This circumstance would lead us to suppose that the gas disengaged is hydrogen, which at the moment of the formation of the suboxide is employed in the reduction of the oxide. But what is more curious is that the phenomena is not produced under two conditions:—(1) when the platinum wire has been freed for some instants from the chlorine, or has been wiped; (2) when the mercury has served as the negative electrode, and has been able to condense a sufficiently large quantity of hydrogen gas to furnish a secondary electric action, as in Planté's secondary battery. This condensation is visible to the eye, for at first when the mercury constitutes the negative electrode no bubbles of gas appear; it is only later that they appear. This phenomena, apart from the rest, has nothing extraordinary if we consider that palladium and nickel can condense considerable masses of hydrogen, and that M. Favre has formed a battery of copper and palladium with condensed hydrogen, in which the gas plays the part of the positive metal. If this manner of interpreting the phenomena be true, the positive electrode put in contact with the mercury after the removal of the negative electrode, should constitute a local gaseous couple (chlorine and hydrogen), which, determining at the contact of the two metals the formation of hydrochloric acid, developes, by the action of this acid, a new electro-motive force in the same direction as that of the gaseous couple, and, consequently, an energetic local current, in which the mercury is negative and disengages hydrogen. But as a fresh disengagement of chlorine results from this local current, it continues for some time. Thus much is certain, that when the mercury has served as a negative electrode for some instants, and we then leave it, it disengages bubbles of gas for some time, diminishes in volume, and ultimately resumes its hemispherical shape. The same effects are exactly reproduced with cyanide of potassium (white and yellow), commercial potash, and even with chloride of ammonium. With the last salt, we reproduce in an interesting manner the curious effect of ammonium alloy. When the solutions are slightly fouled by the residue of the mercurial oxidations, we can easily discover around the drop of mercury the presence of very energetic liquid currents directed from the electrode that gives the least disengagement of gas to that which gives the most. We find in effect that the drop of mercury which is interposed between the two electrodes is polarised in two different manners;* consequently, the part of the drop which is elongated from the electrode where the gas is disengaged liberates gas more quickly than the other part. Under these conditions it will sometimes happen that the drop of mercury will rotate on its own axis with great speed. It is probable that these effects are caused by the increase in volume of the mercury from the absorption of hydrogen gas and the mechanical action of the liquid currents. The flattening of the drop, and its enlargement in all directions when one of the electrodes is plunged into the centre of the drop, is easily explained; it is sufficient to consider that in this case the entire surface of the mercury receives the pressure of the gas developed at every point.

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* "Phil. Trans.," 1864, p. 195.

† "Brit. Assoc. Report," 1862, p. 137.

* This word is employed in the original to embody an abstract idea of movement in the mercury.—[Trans.]

M. DU MONCEL'S REPLY
ON THE
"CONDITIONS OF THE MAXIMUM RESISTANCE OF GALVANOMETERS."†

I ARRIVE at the same conclusions with the formula I stated, when I take for the variable the size of the wire. I said only that, in reality, the number of turns was not represented by the square root of the resistance of the magnetic helix, as is supposed in the incomplete formula I have discussed; and I may show that, in taking into account the different action of the turns, according to their greater or less distance from the magnetic centre, as has been experimentally demonstrated and proved by the law itself of the proportionality of the magnetic force to the number of turns, we increase the energy of the magnetic moment by giving to the wire of the multiplier *a length greater than that which shall render its resistance equal to the resistance of the exterior circuit.* I will quote from my "Exposé des Applications de l'Electricité," vol. ii., p. 16, 3rd Edition, the conclusions to which, in the case of electro-magnets, I have been led:—

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* We can visually demonstrate this different polarity by placing two electrodes in salt water by the side of a drop of mercury. It then presents two colours which meet at the centre. One of these colours is brown, and corresponds to the negative electrode; the other is white, and corresponds to the remaining electrode.

† This reply is to M. Raynaud, who made a similar objection to that advanced in this Journal by Mr. Oliver Heaviside.

1. If we vary g, that is to say the diameter of the wire of the electro-magnet, *the conditions of maximum correspond to the equality of the two resistances R and H.* This deduction signifies that, for an electro-magnet *of given dimensions* a, b, c, the greatest possible force obtained with the least possible resistance of the circuit is produced when the size of its wire *renders its resistance equal to that of the exterior circuit.*

2. If we vary a, that is to say the depth of the coil, the conditions of maximum indicate that the resistance of the electro-magnet should be superior to the resistance of the exterior circuit, in the relation of 1 to $\frac{a+c}{a}$; this signifies that a wire of *given size* g, can—by being coiled around an electro-magnet, the iron core of which has a given length and diameter c and b—increase advantageously the electro-magnetic force, until the resistance of the helix shall equal that of the circuit multiplied by $\frac{a+c}{a}$.

These deductions, therefore, do not contradict the admitted solution. The practical conclusions are, if they are not foregone by the dimensions of a multiplier, which is generally the case, that the maximum sensibility corresponds to a resistance of the exterior circuit smaller than its own resistance; but that, if we seek among several multipliers of the same dimensions, wound with wires of different sizes, the galvanometer to which we should give the preference will be that of which the resistance of the wire approaches as nearly as possible that of the exterior circuit.

POLARISATION.

So much interest is shown by our correspondents in the difficult subject of polarisation that we have determined to collate into a series of papers the opinions and deductions of foreign scientists. Reference will be made, *en resumé*, to the labours of our countrymen, and these remarks will include the description of several original experimental results with which we have been favoured. The chief labourer in this field recently is the Count du Moncel, and we will commence the series with a translation of the table and accompanying article from the *Comptes Rendus*, on the effects produced by electric currents on mercury immersed in different solutions.

"In my last two communications on the action produced by currents upon mercury immersed in solutions of sea-salt, of cyanide of potassium, &c., I have principally attributed the origin of the secondary current, which is produced at the same time as the current of polarisation, to a resultant action of the combination of the two gases disengaged at the two electrodes; but some later experiments have shown me, as I have indicated in *Les Mondes* (24th April), that the effect is more complex, and is related to the action of the metals entering the saline solutions and the amalgams of mercury under electric influence. Having removed the globule of mercury from the electrolytic solution, and washed it with distilled water, the water became alkaline. After this experiment there was no longer a doubt that an amalgam of sodium and potassium is formed in the same manner as the ammonium-amalgam with a solution of sal-ammoniac. The effects which I have described are thus capable of very simple explanation.

"The work I have since undertaken on this question has shown me that, conformably to the observations of M. Planté, the mercury employed as electrode in an electrolyte may involve the creation of secondary currents, more or less powerful, according to the energy of the chemical effects developed by the mercurial electrode, whatever may be its polarity.

"When mercury constitutes the negative electrode, these secondary currents accrue most often from the amalgams formed, and the energy of these currents depends upon the degree of oxidability of the metal alloyed with the mercury, the degree of concentration of the solution, the greater or less facility with which these metals alloy with the mercury, and, finally, upon the stability of their saline combination. The extension of action of these currents, on the other hand, appears to be in relation with the time of electrolysation, and to depend upon circumstances which permit a larger quantity of the metal to amalgamate with the mercury. Generally, the first action of those secondary currents, which is similar to that of the polarisation current from the reaction of gaseous elements, remains nearly the same for from five to fifteen minutes, but the differences increase after five to ten minutes' interruption of the polarising current. Sometimes, also, there is formed upon the negative electrodes, when these are inoxidisable, particular deposits which, without being a metal, are susceptible of furnishing an energetic chemical reaction: this occurs with the solution of sal-ammoniac when the negative electrode consists of a plate of platinum; there is then produced a secondary current, most transient it is true, which attains at the first moment an intensity of 40°, whilst with ammonium-amalgam the intensity is only 56 to 60. It may be remarked that the platinum plate is covered with a brown deposit, which is strongly adherent.

"One important point is, that a very small proportion of a salt is capable of furnishing a very energetic secondary current. Also, that a solution of pure sulphate of binoxide of mercury does not give rise to an appreciable secondary current. Bicarbonate of soda or sulphate of zinc, however, affords a most energetic current. It is from this cause that sulphate of mercury batteries, when they are new, polarise but little, and when they have been some time in use become very inconstant, because the mercury reduced in contact with the carbon is surrounded by a solution more or less impregnated with sulphate of zinc, or with other salts which always exist in the commercial sulphate of mercury. It is for this reason that I have advised the construction, for this kind of battery, of porous cups with a double bottom pierced with holes, in order to isolate the carbon from the mercury and from the liquid charged with sulphate of zinc.*

"When the mercury constitutes the positive electrode there are also produced very energetic secondary currents, which more often occur from oxidation of the mercury, and the reduction of the salts by the hydrogen condensed on the negative electrode. These currents are much less permanent than those which are set up by the negative electrode. The most important occur with solutions of sulphate of soda, sulphate of zinc, sulphate of iron, and sal-ammoniac. Sometimes the currents are more energetic, for the same solution, than when they are obtained by a negative mercurial electrode. At other times the contrary obtains; and in order to give an idea of the nett results, I have composed the accompanying table, which indicates not only the intensity of the currents after different periods of interruption[*] of the polarising current, but also the initial current due to the action of the solution on the mercury. These intensities were given upon a sine galvanometer of 24 turns, with a resistance equal to 12 kilos. of telegraph wire (4 m.m. diam.). The primary current was derived from a battery of eight Chutaux elements, charged some time before, and the figures are the mean of a certain number of experiments, made at different times. The experiments were difficult to perform, on account of the inconstancy of the currents.

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* See my "Exposé des Applications de l'Electricité, 2nd edition, vol. v., p. 91.

Solutions. Salt, 1; water, 4.	Initial Current before Electrolysation.	Intensity of Secondary Current.								
		Mercury Negative.			Mercury Positive.			Negative Platinum Plate.		
		After 0′.	2′.	5′.	After 0′.	2′.	5′.	After 0′.	2′.	5′.
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
Distilled water	0 0	2 0	0 0	—	1 3	0 0	—	2 0	0 0	—
Spring water	0 6	9 0	1 3	0 0	3 3	0 0	—	4 0	0 0	—
Acidulated water (1 to 10)	0 40	4 0	0 0	—	15 0	2 3	—	5 0	0 0	—
Chloride sodium.. ..	0 10	25 0	20 4	11 25	6 0	0 0	—	15 3	0 35	0 0
Potash	0 20	25 0	14 0	7 45	6 0	0 0	—	16 3	0 12	0 0
Bicarbonate soda ..	0 20	35 0	25 0	20 1	13 0	0 0	—	6 0	0 0	—
Sulphate soda	0 42	30 0	18 3	16 4	31 0	0 0	—	12 1	0 55	0 0
Sulphate lime	0 0	16 3	6 0	4 0	13 0	0 0	—	6 3	0 0	—
Sal-ammoniac	0 18	56 0	3 3	0 0	40 0	2 3	0 0	40 0	1 35	0 24
Oxalate ammonia ..	0 0	27 0	0 0	—	19 0	3 0	0 0	3 3	0 0	—
Sulphate mercury ..	2 30	5 0	0 0	—	4 0	0 0	—	2 0	0 0	—
,, zinc	0 0	17 3	3 48	1 48	36 0	3 0	1 3	19 15	4 1	3 0
,, copper.. ..	0 0	5 0	0 0	—	13 0	0 1	0 0	3 0	0 0	—
,, iron	0 10	16 3	0 4	0 0	30 0	1 3	0 0	23 0	4 1	2 3
,, magnesia ..	0 0	8 3	0 0	—	4 0	0 0	—	4 3	0 0	—
,, alumina ..	0 28	15 3	3 3	2 15	16 3	3 0	0 0	7 3	0 0	—
Nitrate ammonia ..	0 30	8 3	0 0	—	21 3	0 0	—	6 3	0 0	—
Cyanide potassium ..	0 30	27 0	13 0	0 0	8 1	0 0	—	4 0	0 0	—
Iodide cadmium.. ..	0 0	17 0	6 0	0 0	18 0	2 0	—	26 3	25 0	3 0
Carbonate baryta ..	0 0	5 0	0 0	—	4 3	0 0	—	2 0	[illegible] 0	—

These experiments were made after five minutes' electrolysation.

RESISTANCE OF WIRES.

By JAMES GRAVES.

In a foot-note on page 22 of No. II. of the Telegraphic Journal, it is stated that "it is open to future investigation to determine whether a body which offers a unit of resistance to one cell, offers neither more nor less than a unit of resistance to a hundred cells."

Since reading this I have accurately adjusted two separate ohms of No. 20 German silver wire, and used them as a Wheatstone's bridge.

As a first experiment I put on the third side of the parallelogram a resistance of four-hundredths of a Varley unit (0·04 V. U.), and on the remaining side 1·1 ohm by Varley. These exactly balanced each other with 1 cell, 50 cells, and then 1 cell again, not a shadow of difference being observed on the galvanometer, which was a very delicate astatic mirror, whose resistance was 5854 ohms.

Secondly, I increased the resistance on the third side to 0·81 V. U., which exactly balanced 20·6 ohms, and this arrangement gave the same result with 1 as with 50 cells.

As the resistance of the galvanometer, being very high in comparison with the four branches of the parallelogram, might account for this result, I prepared a mirror galvanometer, bound with 4 yards of No. 16 copper wire, having a resistance of about six-hundredths (0·06) of an ohm.

With the same bridge of equal ohms, I took a length of 30 inches of No. 18 copper wire for the third and fourth sides, and following the bridge round I found a spot at which the balance was perfect; the addition of one-tenth of an inch either side of this spot gave a perceptible deflection. I then measured the length of the two halves, and found them exactly 15 inches each between the points of contact. With 1 cell or with 50 cells the result was precisely the same. Two sides of this parallelogram were of German silver and two of copper; they would therefore be equally affected thermally.

In another experiment I used the same bridge and galvanometer. On the third side I placed ½ an ohm of German silver, and on the fourth side a length of No. 24 copper wire, sufficient to make a perfect balance with momentary battery contacts. This gave the same result with 1 as with 50 cells, alternated three times with an interval between.

With this same arrangement, 1 cell in permanent contact three minutes showed no alteration; 50 cells on three minutes gave evidence of slight motion, which, by making and breaking, could be increased to an oscillation in the direction of an increase in the copper side, showing the unequal effects of heating. Practically, as far as these experiments show, a standard unit of resistance remains the same for low as well as for high power.

Valentia, December 19, 1872.

[We copy this article from the *Journal of the Society of Telegraph Engineers*. As the article is proposed as a refutation of a statement originating with the Telegraphic Journal, it would have pleased us to have received a copy of this commu-

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[*] The times in the original are 2, 5, 10, and 15 minutes; we include 2 and 5 only.—Ed.

nication from the Author. Mr. Graves has, however, made a lamentable blunder. He takes a pair of scales, adjusts them, puts in the pan 1 lb., and again 50 lbs., and finds that these weights are respectively balanced by 1 lb. and by 50 lbs. Considering the eminence of the electrician whose observations he criticises, the refutation is somewhat gratuitous. But Mr. Graves is undoubtedly in good faith. Yet we would refer him to the remainder of the note, which says—"The causes which might operate to throw uncertainty upon this relation are too remote to affect any results which our mechanical contrivances will probably ever enable us to attain." We would further refer him to Faraday's remarks on electric inertia, and later to Prof. Clerk Maxwell's labours on this point, as published in "Electricity and Magnetism."—Ed. T. J. and E. R.]

MATHEMATICS
FOR
NON-MATHEMATICIANS.

By WILLIAM PAGET HIGGS, LL.D.

Division I.—The Algebra of Constant Quantities.

(Continued from p. 153.)

The Equation and the Unknown Quantity.

We have shown how the addition of 3 to 2 and the sum obtained may be shortly written, viz., $3+2=5$. This (again taking a for 2, b for 3, and c for 5), it has also been shown, may be represented algebraically as—

$$a+b=c.$$

From the *sign of equality* (=) connecting the two members, all similar equal quantities so connected are classed under the general term of an *equation*. The *solution of an equation*, or the *solving* of an equation, merely means the working of it out until the *answer* has been found. The *answer* is the *unknown quantity*.

The unknown quantity is generally represented by the letter x, or, if there are more than one, by the letters x, y, or z (known quantities, as we have said, being represented by the letters a, b, c, ... &c.).

Substituting, therefore, the letter x for the letter c in the foregoing equation we have

$$a+b=x \text{ (or the answer).}$$

As we have determined that a shall equal 2 and b shall equal 3, x or the unknown quantity or the answer must equal 5. Thus we have as synonymous terms—

$$a+b=x,$$
$$\text{or } 2+3=5.$$

Now we may so ring the changes on the two members of the equation as to form *new* equations. We say *new*, because for *two equations to be equal* (*or to be equated*) *their results* (*or their x's*) *must be equal*.

To test this, let us add 2 to *both* sides of the equation. We have—

$$2+3+2=5+2, \text{ or } 7.$$

Evidently a new equation, because 5, the former result (or x) does not equal 7. Similarly, if we multiply both sides by 2, or divide them by 2, or take two from them, we shall obtain new equations. We learn, then, that the balance of an equation is not destroyed when we treat in any way *both* sides by the same quantity. This is the characteristic of an equation, and from this characteristic there springs a valuable aid to the solution (or finding the answer to) equations.

Let us try to understand its application.

There is a sign employed in algebra (and sometimes in arithmetic) indicating *subtraction* or *taking from:* the sign is called *minus*, and is −. So that, we may state the equation, $3-2=1$, or $b-a=x$. Suppose we are told (adhering to our former values for a and b) that—

$$a=x-b,\text{*}$$

and that we are to find the numerical value of x. How should we set about doing it?

Evidently we should say, substituting figures, that—

$$2=5-3,$$

or, what is the same thing, $5-3=2$. But we wish to know what x is equal to, and to know this it is evident that all we have to do is follow our direction implied in the equation, to take 3, or b, from the right side of the equation, and add it to the left, and so get back our old form—

$$a+b=c, \text{ or } 2+3=5.$$

Or we may proceed in another way, which is, mathematically, the more accurate. We may add 3, or b, to both sides of the equation, thus—

$$a+b=x-b+b,$$
$$\text{or } 2+3=5-3+3,$$

and as subtracting 3 and adding 3 result in nothing, we have again $a+b=x$. This operation of taking from one side of an equation to add to the other, or *vice versâ*, the equality being preserved, is termed *transposition*.

We ask our students to set to work and repeat this process for themselves with other numbers. They will derive much greater benefit from such practice than they would from puzzling their brains over the unpractical work even now often given in our text-books. I will make clear what I mean by quoting my lamented friend and former master, Prof. De Morgan, who had vast dislike to the then too common method of illustrating the teaching of algebra by examples of useless equations. "In answer," he says, "to a defence sometimes set up, that the system is *practical*, we observe that much of what is done has no reference to any practical end whatever. The great body of the algebraical work of a school consists in questions of multiplication and division which never occur in practice; above all, in the solution of certain *conundrums* called *problems*, producing equations, of the *practical* nature of which the reader shall judge from the following specimens.

"'A person being asked the hour, answered that it was between five and six, and the hour and minute hands were together. What was the time?'

"'A post is ¼ in the mud, ⅓ in the water, and 10 feet above the water; what is its whole length?'

"'A person has two horses and a saddle worth £50; now if the saddle be put on the back of the first horse it will make his value double that of the second, but if it be put on the back of the second it will make his value triple that of the first; what is the value of each horse?'

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* The student will understand that I am dealing with these simple quantities in order that he may not have to think of the actions of his mind; for he will presently perceive that what is true of, and can be done with, these simple quantities, is as equally true of others, however complex.

"Now if all this be meant for improvement in theory, no one will deny that the reasons of all the rules should be previously understood; but if they be practical questions, we need only say that people have more pertinent methods of answering the question 'What's o'clock?'—that no one concerns himself about the proportion in which a post is shared between wind, water, and mud,—and that the Newmarket gentry have a better way of determining the value of their horses than by involving them, saddles and all, in a simple equation."

Far be it, however, that we should condemn the general system of teaching; we wish to encourage the disheartened student who may have succumbed not for a want of energy, but its waste.

Next we shall have to deal with *negative* quantities, or those quantities erroneously valued as "less than nothing."

Students' Column.

The Laws of the Heating Effects of Currents.

By H. R. Kempe.

A great deal of misapprehension exists as to the heating effect of a current on wires of different resistances. This misapprehension arises generally from the impression that the heating effects of a current on a wire is due simply to the resistance which it has to overcome.

A simple analysis of the laws of heating by currents will enable us to find the real facts of the case.

The first and most important law is that of Joule, which states that the quantity of heat H developed in a given time t in a circuit whose resistance is R with an intensity of current I is—

$$H = I^2 R t$$

I the intensity of the current by Ohm's law equals—

$$\frac{E}{R}$$

E being the electromotive force of the battery. Substituting this value of I in the first equation we get—

$$H = \frac{E^l t}{R}$$

This law shows first that with a battery of a given electromotive force E acting for a given time t, the total amount of heat developed in the circuit (battery included) will be inversely proportional to the *total* resistance in circuit; that is, for example, if we double one *total* resistance we have one *total* amount of heat developed.

To render this clearer, let us suppose our battery and wire joining its poles to be immersed in a liquid, so that the heat developed in the circuit may be communicated to this liquid. We should find that if with a *total* resistance in circuit of 100 ohms the temperature of the liquid, in say 10 minutes, rose from 60° to 80°, then if that total resistance were 200 ohms the rise in the same time would only be from 60° to 70°.

If the current with the 200 ohms in circuit was kept on for 20 minutes instead of only for 10 minutes, we should find that the temperature would rise to 80°, as at first, thus showing that the total amount of heat developed is directly proportional to the time the current is kept on.

Lastly, the law shows that when the total resistance in circuit is constant, and the time also constant, the amount of heat developed in the circuit is directly proportional to the electromotive force of the battery squared; thus we should get *four* times as much heat developed by 4 cells of a battery as by 2 cells, for the electromotive forces would be in the proportion—

$$2^2 : 4^2, \text{ or } 1 : 4$$

As the total resistance R is compounded of the resistance of the battery and the external wire resistance, it is better to write the formula—

$$H = \frac{E^l t}{R}$$

$$\text{as } H = \frac{Et}{\nu + \rho}$$

ν being the external wire resistance, and ρ the resistance of the battery; now if we regard the heated wire to be composed of a number of short lengths, the quantity of heat developed in two or three of these pieces will be twice or thrice that developed in one; and as two or three of these pieces will have a resistance twice or thrice as great as one piece, so it follows that the amount of heat developed in the battery will be to the heat developed in the external resistance as—

$$\rho : \nu$$

We get then that—

$$H = \frac{E^l t}{\nu + \rho}$$

being the total amount of heat generated in the circuit, that generated in the battery will be—

$$h = \frac{E^2 t'}{\rho + \nu} \times \frac{P}{\rho + \nu}$$

that is—

$$h = \frac{E^l t \rho}{(\rho + \nu)^2}$$

and the heat developed in the external resistance—

$$h' = \frac{E^l \nu}{(\rho + \nu)^2}$$

It is interesting to know what is the best resistance to employ between the poles of a battery, so as to develope a maximum amount of heat in that resistance.

A high resistance would have the effect of weakening the power of the current, and a low resistance would not allow of much heat being developed in it. The point then to be determined is, what value of ν in the equation—

$$h = \frac{E^l t \nu}{(\rho + \nu)^2}$$

makes h, a maximum—

$$\frac{dh}{d\rho} = \frac{E^2 t(\nu - \rho)}{(\nu + \rho)^3} = 0 \text{ at a maximum;}$$

therefore— $\nu = \rho$,

which shows that the greatest possible amount of heat will be developed in the resistance external to the battery when its value is the same as the battery itself.

To develope the greatest possible amount of heat in the entire circuit, we must make the denominator of the fraction—

$$\frac{E^l t}{\rho = \nu}$$

as small as possible, which can only be done by making $\rho=0$, that is the battery must be short circuited.

It is important not to confuse the *quantity of heat developed* in a wire with its elevation of temperature. The *quantity of heat developed* in a wire one foot long and 0·001 square inch in section is the same as that developed in a wire two feet long, and 0·002 square inch in section; the elevation of temperature is, however, very much less in the latter than in the former case, because we have four times the amount of metal to heat in the longer and thicker wire than in the shorter and thinner one, although the resistance in both cases is the same; also the larger wire has a greater surface exposed to the air than the smaller one.

When the current is passed for so short a time that the heat emitted and lost may be neglected, then, if the intensity of the current remain constant, the elevation of temperature varies *directly* as the resistance per unit length, and is also directly proportional to the bulk or weight per unit length.

Now for a unit or given length the resistance is *inversely* as the section of the wire, or as its radius^2, and the bulk or weight is *directly* proportional to the section or radius^2; therefore, combining the two, the elevation of temperature will be inversely as the square of the sectional area of the wire, or as the radius^4; thus, a wire 1 foot long and $\frac{1}{100}$th of an inch in radius will be heated to a temperature 16 times as great as one $\frac{2}{100}$ of an inch in radius: first, because having only one half the radius, and consequently one-fourth the sectional area, it has four times the resistance of the greater wire; and secondly, because there is four times the amount of metal to heat.

If we suppose the wire to have become heated up to its permanent temperature, then bulk can obviously have no influence on the elevation of temperature, for the battery goes on supplying heat until the whole of the wire has become heated to its maximum temperature. But now the question of surface comes into play, for the greater the surface the greater the facility for the emission and loss of heat. By Newton's law, the heat emitted from a heated wire is approximately directly proportional to its circumference, and also to its elevation of temperature; this is expressed by the simple expression—

$$\text{heat emitted } = 2\pi\nu Bx$$

where ν is the radius or diameter of the wire, x the elevation of temperature, and B a constant depending upon the kind of metal of which the wire is composed, &c.

The heat received is $\frac{A}{\pi\nu^2}$, A being another constant for the heat received has not, like that emitted, to pass through the air. These expressions being equal—

$$2\pi\nu Bx = \frac{A}{\pi\nu^2}$$

therefore—

$$\nu^3 x = \frac{A}{B 2\pi^2} \text{ a constant,}$$

which shows that in this case the elevation of temperature is inversely as the radius^3.

PAPERS FOR JUNIOR STUDENTS.

Specific Resistance of Metals.

We have just learned somewhat of the meaning of resistance. When we have studied the construction and use of the galvanometer we shall be enabled more easily to determine the resistance of particular substances. It should be remembered that every metal—it might be said every substance—has a resistance peculiar to itself; this resistance is termed the *specific* resistance of the metal or subject under investigation. M. E. Becquerel has determined the specific resistance for a unit of length and given thickness of the following metals, *at a temperature of 15° C., the resistance of silver at 0° C. being denoted by* 100.

SPECIFIC RESISTANCES OF THE PRINCIPAL METALS AT 15° C.

Silver	107		
Copper...	112	Palladium	715
Gold	155	Iron	825
Cadmium	407	Lead	1213
Zinc	414	Platinum	1243
Tin	734	Mercury	5550

The student should notice that whereas the resistance of the same length of silver taken at 0° C. —or zero of temperature—is 100, at 15° C.—or with 15 degrees of heat—it is 107, showing that the resistance of metals increases with heating, or, in other words, with a rise in temperature. Dr. Matthiessen has measured the amount of this increase, but he regarded the increase in resistance from an opposite point of view,—that is, he looked upon increase of resistance in its reciprocal relation as a decrease in the conductibility of the metal. Following out this view he gave, in the following table, the results of his investigations with metals at 0° C.

Silver	100		
Copper	99·9	Iron	16·80
Gold	80·0	Tin	13·10
Aluminium ...	56·0	Lead	8·30
Sodium	37·0	German silver...	7·70
Zinc	29·0	Antimony... ...	4·60
Cadmium	23·7	Mercury	1·60
Potassium	20·8	Bismuth	1·20
Platinum	18·0	Graphite	0·07

Dr. Matthiessen also found that the law of decrease in conductibility or increase in resistance by a rise in temperature is expressed by the following formula:—

$$C^t = C^\circ(1 - at + bt^2),$$

where C^t and C° are the conductivities at t° and 0° respectively, t being the increase in temperature (C°). a and b are constants, which Dr. Matthiessen found by experiment to be for ten pure metals,—

$$C^t = C^\circ(1 - 0{\cdot}0037647\,t + 0{\cdot}00000834\,t^2).$$

For several alloys and for mercury there are different values for a and b, viz.—

	a.	*b.*
For mercury	0·0007485	−0·000000398
,, German silver ...	0·0004433	+0·000000152
,, platinum+silver	0·0003100	——
,, gold+silver ...	0·0006999	−0·000000062

Dr. Matthiessen found that when two metals are alloyed the resistance of the alloy is generally greater than would be inferred from calculation based on the resistances of the two metals which compose the alloy. But, on the other hand, alloys have not their resistance so readily affected by heat as have pure metals. Consequently certain lengths of wire kept for the purpose of making electrical measurements, and termed *resistance coils*, are constructed of German silver. Besides the advantage derived from less liability to be affected by temperature, there are other advantages; amongst them the convenience which German-silver wire affords, from its high specific resistance compared with that of iron wire, of obtaining in a small space a length of wire equal in resistance to many miles of iron telegraph wire. Some standard resistance coils[*] are constructed of silver and platinum, silver and gold, &c.

The process of annealing metals also changes their specific resistance. The following tables, condensed from Müller's researches, explain at a glance the effect of subjecting metals to high temperatures.

IRON WIRE.

Temperature.	Resistance.
0° C.	640
21° C.	691
285° C.	1660
Commencing to colour	22250
Dark grey	2460
Scarcely incandescent	3050
Dark red	3200
Bright red	3650
Red-hot	4550
White-hot	4880
Again 21° C.	727

Thus the permanent difference (727−640)=87 is due to the effects of heat. Again, with copper and platinum wires:—

COPPER WIRE.

Temperature.	Resistance.
0° C.	814[†]
21° C.	864
Scarcely incandescent	2100
Red	2450
Bright red	4700
21° C. (cooled)	910

PLATINUM WIRE.

Temperature.	Resistance.
0° C.	1870
21° C.	1986
Barely incandescent	4300
Red-hot	4700
21° C.	1984

Impurities, too, may be regarded as having the effect of alloys in increasing the resistance of a metal.

There is a practical point to be gained from the consideration of these tables. It is that pure copper has very nearly indeed the conductivity of pure silver. Consequently, however plentiful silver might be, there would arise, practically, no advantage from its use instead of copper. And it would have assisted practical electricians very much had some experimentalist taken copper instead of silver for his standard in estimating the specific conductivity of other metals.

Resistance of Liquids.

The resistance of liquids is a subject of which we have but little true knowledge. There are two difficulties in the way of making measurements of the resistance of a liquid that can be decomposed by the electric current: these are (1) polarisation, or the liability of converting the liquid measured into a voltaic element giving another electromotive force opposed to that of the testing-battery, and (2) the difficulty of maintaining the liquid at the same density or strength during comparative measurements. Fortunately the practical requirements of telegraphy do not call for accuracy in the measurement of the resistance of liquids, and it is sufficient for us to know the approximate relation of the resistance of one liquid to that of another. It is in setting up batteries only that the telegraphist has occasion to regard the resistance of the liquid he employs. Taking the standard pure silver as one hundred millions (for liquids are *very* bad conductors), M. Ganot gives the following resistances of various liquids:—

Pure silver	100,000,000
Sulphate of copper (saturated solution)	5·42
Common salt (saturated solution)	31·52
Sulphate of zinc (saturated solution)	5·77
Sulphuric acid, 1·10 commercial	99·07
Nitric acid, commercial	88·68
Distilled water	0·01

The effect of heat upon liquid conductors is to *decrease* their resistance in a proportion expressed by the formula $C^t = C^\circ(1 + at)$, where a for sulphate of copper is equal to 0·0286. There are various properties possessed by liquids when exposed to the action of the electric current upon which it is needless in this place to dwell.

When we have considered the resistance of insulators enough will have been said about the various phases of resistance to enable us to understand the application of instruments to its measurement.

Proceedings of Societies.

ROYAL SOCIETY.

May 8, 1873.

FRANCIS SIBSON, M.D., Vice-President, in the chairf

The following paper was read:—"*The Action o Light on the Electrical Resistance of Selenium*," by Lieut. SALE, R.E.

It having been recently brought to notice that selenium in the crystalline condition exhibits the remarkable property of having a conductivity varying with the degree of light to which it is exposed, the following experiments were undertaken with a view to the further elucidation of the matter:—

Experiment 1.—A bar of selenium, measuring approximately 1·5″×0·5″×0·05″, was procured, and platinum wire terminals were fastened to the ends.

The bar itself was then enclosed in a box having a draw-lid, so as to admit or exclude the light at pleasure.

Then, the lid of the box being on, the resistance of the selenium was measured by means of a high-resistance galvanometer and a Wheatstone's bridge, with dial-coils capable of measuring up to 10,000,000 ohms. The battery power was 2 cells Daniell. The measurement was made on a dull, cloudy day, and in a room of equable temperature.

The resistance having been carefully balanced, the lid of the box was withdrawn, when the resistance of the selenium fell instantaneously and considerably, as indicated by the rapid movement of the spot of light on the galvanometer-scale.

Experiment 2.—The transition from darkness to the light given by an ordinary gas-burner (conditions as before), caused a slight and barely perceptible fall in the resistance.

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[*] We shall presently describe very fully the construction and use of resistance coils.

[†] A finer copper wire was employed.

Experiment 3.—The bar of selenium was next tried in the solar spectrum on a very bright cloudless day (conditions as before), except that more battery power was used (10 cells Daniell). The diffused daylight could not be cut off; so the trial was made in the most shaded part of an ordinary room, the spectrum being superimposed in the ordinary diffused daylight. The resistances were very carefully balanced in each case, with the following results:—

Resistance in darkness	330,000
,, ,, violet	279,000
,, ,, red	255,700
,, ,, orange	277,000
,, ,, green	278,000
,, ,, blue and indigo ..	279,000
,, ,, centre of red	255,000
Resistance just on the outside edge of red, red side	220,000
Resistance in dark rays clear of red	228,000
,, ,, diffused daylight only	270,000
Resistance taken in the dark immediately after exposure (resistance rising)	310,000

The indications were very clear; and the bar of selenium was so sensitive to the action of the spectrum, that a slight movement of the prism produced a corresponding movement in the spot of light on the galvanometer-scale.

It is to be noted that in this experiment the reflecting galvanometer was placed on a heavy masonry pillar insulated from the floor for observatory purposes, and that the battery, bar of selenium, and resistance-coils were in another room, being connected by long and carefully insulated leads with the galvanometer.

Experiment 4.—The diffused light was cut off as much as possible by screens; and the resistances were again balanced in the solar spectrum. Conditions as in the last case.

Resistance of selenium in red ..	240,000
,, just outside red	240,700
,, in blue	270,000
Resistance in such diffused light as came through screens..	290,000
Light cut off by lid of box (resistance rising)	310,000

Experiment 5.—The selenium was also exposed to the spectrum of the electric light in a darkened room.

The effect was feeble; but by using more battery-power in balancing, it was possible to measure the swing of the spot of light when the selenium was suddenly exposed to the action of the light of the spectrum. The maximum effect was obtained in or just at the edge of the red, the violet and blue rays producing scarcely any effect.

Experiment 6.—The selenium was exposed to the full sunlight; the resistance fell enormously and instanteously, and on balancing it was found to be little more than half what it was in the darkness.

The following were the general results of the experiments:—

Results.—(1). That the resistance of selenium is largely affected by exposure to light.

(2). That this effect is not produced by the actinic rays, but is at a maximum at or just outside the red rays, at a place nearly coincident with the locus of the maximum of the heat-rays.

(3). That the effect of varying resistances is certainly not due to any change of temperature in the bar of selenium.

(4). That the effect produced on exposure to light is sensibly instantaneous, but that, on cutting off the light, the return to the normal resistance is not so rapid.

It would seem that there exists a power in rays nearly coincident with the heat-rays of high intensity, of altering instantaneously and without change of temperature the molecular condition of this particular element.

May 15.

A paper "*On the Determination of the Number of Electrostatic Units in the Electro-magnetic Unit made in the Physical Laboratory of Glasgow University*" was read by DUGALD M'KICHAN, M.A. The object of this paper is to describe experiments made at intervals from 1870 to 1872 in the Physical Laboratory of Glasgow University to determine the relation between the fundamental units in the two systems of absolute electrical measurement, the electro-magnetic and the electro-static. A summary is also given of the results of similar observations made by W. F. King in 1867 and 1868.

The two systems of electrical measurement, or the units which they employ, are founded on the fundamental units of time, mass and space applied to the observed effects of electricity at rest, and electricity in motion. The dimensions of quantity in the two systems are such that the ratio of the electro-magnetic and the electro-static unit of quantity is expressible as a velocity.

This velocity, usually known as v, is not only of great importance in all combinations of electro-magnetic and electro-static action, but it is also of great scientific importance in the theory of the propagation of electro-magnetic disturbances through a dielectric medium. It occupies a very important place in the development of the electro-magnetic theory of light by Prof. Clerk Maxwell, according to whose theory this velocity v is the same as the velocity of light. The first experimental determination of v was made by Weber from a common electro-static and electro-magnetic measure of capacity. As the result of Weber's experiments, v was found to be $310{\cdot}74 \times 10^8$ centims. per second.

Another determination was made by Prof. Clerk Maxwell in 1868, by means of a direct comparison of electro-static attraction with electro-magnetic repulsion. His experiments gave $v = 288{\cdot}0 \times 10^8$ centims. per second.

The value of v given by the experiments here dedescribed is 293×10^8 centims. per second. The method employed was that of obtaining an absolute electro-static and an absolute electro-magnetic measurement of the same electromotive force. v is defined as the ratio of the units of quantity in the two systems; but it follows from the definition of electromotive force, that v is also the ratio of the units of electromotive force in the two systems. The electromotive force, or the difference of potentials between the two poles of a constant Daniell's battery, was measured electro-statically by means of Sir William Thomson's absolute electrometer. The absolute electro-magnetic value of this electromotive force was given by the effect of the current which it maintained in the circuit of an electro-dynamometer. The determination of this value depended on the resistance of the value of the British Association standard unit of resistance. Any correction which may hereafter be found to be applicable to the absolute value of this standard coil, as measured at King's College by Professors Clerk Maxwell, Balfour Stewart, and Fleeming Jenkin, must be applied to the value of v given above.

The comparisons made in 1867 and 1868 by Mr. King gave as the mean value of v, $284{\cdot}6 \times 10^8$ centims. per second.

The experiments made in 1870 with the new absolute electrometer gave as the mean result $v = 294{\cdot}5 \times 10^8$ centims. per second. The result of later observations made under much more favourable circumstances was $v = 292{\cdot}4 \times 10^8$ centims. per second.

The latest observations (1872) furnish the most probable value of v, 293×10^8 centims. per second.

Inventions.

ELECTRICAL COMMUNICATION ON RAILWAY TRAINS.

Mr. E. Gilbert, telegraph engineer and superintendent, North British Railway, proposes a system of communication on trains, which he states has the following advantages:—Audible and visible signals between guard and driver, passengers, during accidental separation, without disturbing the communication on the proceeding portion of the train, should a section of the train become detached. A cable runs from guard's to driver's van through the whole length of the train. The coupling from carriage to carriage is effected by short cables, the ends of which are inserted into sockets attached to each carriage. These sockets, by an ingenious mechanical arrangement, are so constructed that, while in the event of a carriage being "slipped" while the train is in motion—a thing frequently done in the case of express trains,—the removal of a small peg enables the wire to be thrown off without bringing the electric apparatus into operation; but should the train from any accidental cause be separated into two portions the jerk pulls the cable, peg and all, out of an inner socket, and when this is done, the electric circuit is completed, and the bells at both ends of the train begin to ring. The train to which the apparatus is now attached has been for some days running between Edinburgh and Glasgow—twice each way; and in the instructions to the guards of that train, a code of signals has been provided. By one continuous ring of the electric bell, the train is signalled to stop instantly—this signal corresponding to the unbroken ringing that would be caused by any panic-struck passenger who might bring the apparatus into play, or by the splitting of the train into two by accident. Two distinct rings form the signal to start a train, and three for the engine-drivers to "look-out." The system of signalling is capable of extension to maintain any necessary communication between guards and driver, while it affords a ready means whereby upon emergency any passenger may have a fast train brought to a standstill; and also provides for the alarm being given should a train, as sometimes happens, become detached at the couplings.

Notices of Books.

Electricity and Magnetism. By FLEEMING JENKIN, F.R.SS. L. & E., M.I.C.E., Professor of Engineering in the University of Edinburgh. Text-Books of Science. London: Longmans, Green, and Co. 1873.

IN his preface, Prof. Jenkin says:—"The difference between the electricity of the schools and of the testing office has been mainly brought about by the absolute necessity in practice for definite measurement. The lecturer is content to say, under such and such circumstances, a current flows or a resistance is increased. The practical electrician must know how much resistance, or he knows nothing; the difference is analogous to that between quantitative and qualitative analysis."

To have recognised this difference is a great step in advance upon former electrical teaching; but we are somewhat disappointed with the result, if this new work of Mr. Jenkin's is to be taken as a criterion of that recognition. Not that we would infer the work to be devoid of merit; far from it. But we are disappointed. Quoting again from his preface, Mr. Jenkin tells us:—"The book has been unfortunately written in intervals snatched from professional engagements at irregular periods." Now we would have been content to have waited until so much time had been devoted to his work as had given Mr. Jenkin more confidence in offering the book to students. He, too, seems to think the work has fallen short of its mark. As a whole, then, we commend the work, but in detail there are one or two remarks (we will take them *seriatim* with the pages of the work) which may be selected as instances of the error arising from hurried publication.

At page 18, the author says, speaking of the electricity distributed on two conductors separated by a thin dielectric:—"If I allow *both* to be in connection with the earth or with one another for a single instant, the electricities will instantly combine and neutralise one another." Now, no solid dielectric allows an instantaneous neutralisation; the discharge on electrification taking with some materials many hours. This statement is quite opposed to the true statement made under the head of Absorption in the same work, and shows a little want of care in stating facts. A less important instance occurs (on page 19) in the figures (10 and 11), illustrating the same distribution of electricity on two conductors, where the shape of the dotted curves is wrong—the greatest density being always at the edges and not in the middle of a plate. Now, with regard to practice, the use of the terms "megavolt," "micro-volt," should not have been tacitly adopted by an electrical engineer of Mr. Jenkin's standing, for he must know they are *not* "units employed in practice," nor have these terms any chance of ever being used for any purpose whatever. Again, the long table (page 162), with its monotonous repetition of powers of 10, might advantageously have been condensed in the following form, which contains all the relative values of the B. A. units entering into electrical work:—

	B. A. Units of.	Name.	Equivalents in Electro-magnetic Units.	Equivalents in Common Units.
1.	Resistance.	"Ohm."	10^7	1·049 Siemens's units.
2.	—	"Megohm,"	10^{13}	1049·000 Ditto.
3.	Electromotive force.	"Volt."	10^5	0·927 Daniell's.
4.	Current.	—	10^{-2}	$0{\cdot}884 \dfrac{1 \text{ Daniell.}}{1 \text{ Siemens.}}$
5.	Quantity.	"Weber."	10^{-2}	—
6.	Capacity.	"Farad."	10^{-7}	—
7.	—	"Micro-farad."	10^{-13}	About 3 knots of cable core.

Peltier's discovery, that a current flowing through a circuit composed of two metals heats one junction and cools the other, is not so well explained as could be desired in a text-book of electrical science. The conversion of heat into electricity and of electricity into heat is clearly laid down, but a student might not quite see his way through the conversion of electricity into cold. The absorption of heat at one juncture, and its release at the other, is very crudely stated.

In two points the book is admirably adapted to the purposes of the student. Mr. Jenkin has carefully avoided any distinction between free and bound, or combined electricity, and has consequently avoided also the confusion that must arise in the mind of the student from the use of such a distinction. The other point is the method of teaching adopted. The principal facts of electrical science are first presented without a hint as to their correlation; then, in the subsequent chapters of the work, is defined the correlating principle. By this means dependence upon any particular step in the reasoning is rendered un-necessary, and the student can study the one branch to which he has devoted himself.

But, notwithstanding its merit, the work has not fulfilled the want of a text-book based upon the new theories; it is to be regarded rather as a step in the right direction than as "a consummation devoutly to be wished."

Correspondence.

OPERATORS AND THE INCOME TAX.

To the Editor of the Telegraphic Journal.

Sir,—No doubt you are aware, that in order to facilitate the vast amount of business transacted at the Central Telegraph Department of the General Post-Office, it is requisite that many of the clerks should do extra hours of duty, some working from 8 a.m. till 8 p.m., and are paid at the rate of so much per hour for the number of hours they work "overtime."

To some of the clerks the opportunity of making a little extra money is a great boon, especially if their family be not in very good circumstances, but to others the time perhaps would be of more value.

What I wish to point out to you is this:—That should the amount earned by working late, when added to their salary, exceed £100 at the end of the year, so much is deducted by the authorities on account of income tax. I must say that I look upon it as a very sharp practice, when you consider that the money was fairly earned by working till late for the convenience of the Department, and not from choice. And that if the work were divided by having additional clerks no income tax would be forthcoming.

I trust you will insert this in your Journal as it is useless complaining to those in office. I think that when extra duty is imposed on the clerks they should have what they earn without having a tax imposed upon them as well as extra duty.—I am, &c.,

F. W. O.

Awards to Electrical Science.—The French *Société d'Encouragement* have awarded to Sir Charles Wheatstone, F.R.S., the Ampère medal, for his remarkable works in theoretic and applied physics. A prize of 3000 francs has been awarded to M. Gramme, for the construction of an apparatus giving an electric current constant in direction and in intensity, whose electromotive force and conductibility are equal to those of an azotic acid pile of 60 or 80 elements of ordinary size, and superior, both in economy and solubility, to the apparatus which are at present in use.

Blasting by Electricity.—The Aberdeen *Free Press* says that an experiment was made with electricity as a means of firing blasting charges in Mr. Fife's quarries at Kemnay. A huge breast of rock, calculated to weigh about 2000 tons, was bored in eleven places, charged, and fired almost simultaneously by a current of electricity, from a battery which was under the care of Mr. David Wright, electrician, Aberdeen. The huge mass was started with little noise from the report, but with a rumbling sound like that of distant thunder. A second blasting was fired the next day, and though the ground was covered with snow, and a heavy snowstorm was falling, wires extending 1500 feet in length being laid, and a current of electricity being put on, in an instant a tremendous explosion was heard, which shook the ground like an earthquake. Great masses of granite were upheaved in the air, and about 5000 tons were displaced. It is the largest blast which has ever been witnessed in these quarries, effected by means of electricity applied by a new apparatus, most ingeniously constructed.

Electrical Science in Foreign Journals.

(We intend to devote this column to a list of Electrical Memoirs published in Foreign Journals during the month. Those of importance will be either translated in full or given in abstract.)

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences, Vol. lxxvi., No. 15.

On the Effects Produced by Currents upon Mercury Immersed in Different Solutions.—By M. Th. du Moncel. In my last communication I showed that the mercury in absorbing hydrogen, can, under certain conditions, develope very energetic local currents. I then wished to measure the intensity of these currents with different solutions, and this led me to study the secondary currents created by the polarisation of the electrodes. These are the results at which I have arrived. When we pass the current from a battery of eight Chutaux elements across an electrolyte consisting of ordinary spring water, and the electrodes of which are represented on the one hand by a large drop of mercury and upon the other by a platinum wire put into connection with the positive pole, the polarisation current which results from the formation of the secondary circuit, after five minutes' action of the battery, and through a circuit of 12 kilometres of telegraphic wire, furnishes an intensity represented at the commencement by 7° or 8° upon a sine galvanometer of 24 turns. This current diminishes rapidly in intensity, and at the end of three minutes is scarcely appreciable. In substituting for the mercury a platinum plate of the same surface, the intensity of the current is much less (3° or 4°), and it disappears with equal rapidity, showing that mercury condenses more hydrogen than platinum. With water acidulated to the tenth of its weight, the intensity of the polarising current was less than with spring water, as well with the mercury as the platinum; it disappears with the same rapidity, but the disengagement of gas is more abundant. [Experiments were tried with chloride of sodium, potash, and cyanide of potassium]. With a solution of sal-ammoniac, in which the salt was one-quarter the weight of the water, the effects are very marked, for there is obtained after the action of the battery a secondary current, of which the intensity varies from 45 to 56 degrees, but which disappears with such rapidity that at the end of two minutes it furnishes an intensity of 3°30′ only, and no traces remain after five minutes. This effect proves without doubt the instability of ammonium-amalgam which is formed under the influence of the battery current. In order to appreciate the energy of the action, it is sufficient to know that a bichromate element placed in the current does not give a more energetic current. [M. du Moncel then proceeds to consider that the fact that such an energetic current is obtained from M. Planté's secondary battery may be easily explained by the action of the electrodes of peroxide of lead formed by the primary current].

No. 16.

On the Condensation of Carbonic Oxide and Hydrogen and of Nitrogen and Hydrogen by the Electric Current.—By MM. P. Thenard and Arn. Thenard.—In our last communication (*Comptes Rendus*, 3 March, 1873, *et vide* Telegraphic Journal, No. 117), we made known that the electric induced flux condensed into an oleaginous liquid a mixture of equal volumes of protocarbide of hydrogen and carbonic acid, while the spark, on the contrary, decomposed the mixture into oxide of carbon and pure hydrogen. This difference between the action of the induced flux and the spark merits attention. It became necessary to ascertain if the flux would build up what the spark had destroyed. We therefore submitted to the flux a mixture of equal volumes of carbonic oxide and hydrogen. [The experiment proved the conclusion]. After this experiment, which demonstrated the power of the flux in the manner we had supposed it would, we submitted to its action a mixture of hydrogen and nitrogen in the proportion of 3 to 1. At the end of two hours the odour of ammonia was very perceptible. [The note is concluded by quotations from the writings of MM. Edmd. Becquerel, Fremy, and Chabrier in support of the peculiar action of the electric fluid, and by a promise to give at an early date an analysis of the oleaginous liquid produced].

Action of Electricity on Flames.—Memoir by M. V. Neyreneuf. (Extract by the author).—There has been demonstrated the existence of an electric wind in placing a flame near an electrified point. The experiment is in reality complex, and depends, *inter alia*, upon the nature of the fluid we employ. A flame may be considered as a very good conductor; produced at the extremity of a glass tube well insulated and placed before a point, it attracts the molecules of air that surround this point, and in this manner the wind results. It is susceptible itself of attraction, and with inverse proportionality to the distance of the point; there should therefore exist a certain distance at which the wind acquires a maximum intensity. It is this which I have to make known. If the flame is produced at the extremity of a metallic jet in communication with one of the armatures of a Holtz machine, whilst the point communicates with the other, the electric wind is generally much more intense, but the effects are complex, and follow the relative arrangement of the point and of the flame. Matters arrange themselves always as if the electricity were really propagated in a direction from positive to negative; also a positive point repels the flame, while it is attracted by a negative point. With a Bunsen flame we do not obtain sensible repulsion.

On the Comparison of Electric Machines.—By M. Mascart.—The apparatus for producing static electricity can be compared between themselves as well as ordinary batteries. As the electromotive force and internal resistance of an element determines its value, so an electric machine may be defined by two constants:—1. The difference of potential that it is capable of establishing between two conductors; 2. The quantity of electricity it can supply in a given time. In the following table the Holtz machines were warmed, and all the experiments were made under such conditions as would produce the maximum effect for each instrument:—

	Diameter of plate.	Quantity	
		Per turn.	Per sec.
	m.		
Ordinary Ramsden machine ..	0·97	1·00	1·00
Larger ditto ..	1·62	1·70	1·70
Ditto, with insulated cushions.	0·98	1·00	1·00
Marum's machine	0·84	1·40	1·40
Nairne's cylinder	0·32	0·18	0·27
Holtz ordinary machine	0·55	0·45	4·50
Ditto, with two plates	0·55	0·86	8·60
Ditto, with two plates rotating inversely	0·30	0·23	2·30
Carré's machine, with vulcanite plate	0·50	0·15	1·50
Armstrong's machine	—	—	2·40
Induction coil (large)	—	—	13·00

We perceive that for the first three machines the quantity is sensibly proportional to the diameter of the plate; however, the third machine differs from the first two not only by the insulation of its cushions but by the suppression of the vice or jaws, which were replaced by little cylinders situated at the side only of the disc. At the same time the table does not indicate the relative value of the machines, because the speed of rotation was not the same. Neither have I given the value of the potentials, because there appeared some uncertainty in the numbers obtained.

No. 17.

On the Combinations Formed under the Influence of the Induced Electric Flux by Marsh-Gas and Carbonic Acid and Carbonic Oxide and Hydrogen.—By MM. P. Thenard and A. Thenard.—This is a review of the work done by Sir B. C. Brodie upon this subject (*see* TELEGRAPHIC JOURNAL, p. 140). As we did, Sir B. C. Brodie submitted a mixture of carbonic oxide and hydrogen, and also has observed a contraction of the gas. But his products remain gaseous, and their analysis after five hours' work—for at the end of this time the contraction had nearly ceased—showed there were formed, at the expense of the hydrogen and carbonic oxide, water and marsh-gas, which occurs in the final mixture in the ratio of 6 per cent. In our experiments, on the contrary, the contraction is always maintained, and the condensation has been so complete as to oblige the providing of fresh gas. By great fortune M. Berthelot was present at the first, and M. Fremy at the second examination. [Then follow a series of purely chemical tests, which have not, however, from the negative nature of the evidence, given definite results. The experiments are to be continued].

Observations Relative to a Note by M. du Moncel on the History of the Induced Electric Flux.—By M. Arn. Thenard.—A note relating rather to claims of originality in these experiments than to scientific principle.

No. 18.

Action of Ozone on Absolute Alcohol; Combination of Cyanogen with Hydrogen, under the Influence of the Electric Induced Flux.—By M. A. Boillot.—M. Boillot describes these chemical combinations as effected in his ozonometer (*see* TELEGRAPHIC JOURNAL, p. 117), and says:—The apparatus is always efficient; the results differ only from variations in temperature, and from the quantity of electricity given by the battery, the force of the induction coil, &c.

Third Note on the Effects Produced by Electric Currents upon Mercury Immersed in Different Solutions.—By M. du Moncel.—This will be given elsewhere, under the title of "*Polarisation*," the papers to be continued, and to include the principal deductions on this vexed question made by the most eminent foreign scientists.

No. 19.

On the Carrying Power of Magnets.—By M. J. Jamin.—I have the honour to submit to the notice of the Academy two magnets arranged according to the system I have made known; one carries 80 kilos. and weighs 6, the other carries about 500 kilos. with a weight of one-tenth. The carrying force of a magnet depends upon a complication of circumstances; in the first place the mass of the contact and the exactitude with which it is fitted. If it be small, the magnet retains a portion of its magnetism, and the contact takes at its two extremities two poles of the same name as those which it touches. When the mass is increased, this magnetism diminishes, and at a limit entirely disappears. It is at this moment that the carrying force is greatest, since all the magnetism is in use. Under the conditions formerly stated, the magnetism becomes a maximum, and equal to M; the carrying force attains a limit f, and each plate preserves a quantity of magnetism $e = \frac{M}{n}$, which decreases proportionally with the number n of elements, and which is always inferior to the quantity E, that they have received by magnetisation. The quantity f is the inferior limit of the carrying power; F is the superior limit. [M. Jamin experimentally applies these principles]. From the foregoing facts we can deduce the conditions that will produce the best magnet constructed with steel plates of a given length. 1. The contact should cause the disappearance of the whole of the magnetism of the exterior surface of the magnet. To effect this, the mass must be sufficient. 2. This mass being given, it will be necessary to reduce the adhering surface until we commence to increase the free magnetism that the application of the contact leaves on the magnet. 3. When the length and width are determined, it is necessary that their number should be sufficient to cause the appearance of the least free magnetism on the magnet when the contact is attached. If this number is less, the limit of the permanent force is not attained; if the number exceeds, nothing is gained. 4. The armatures should be strong, well applied, and in close contact; especially we should not exaggerate their weight. Following these conditions, I have constructed a magnet which I submit to the Academy. Two armatures, each weighing 16 kilos., placed *vis-a-vis*, are firmly fixed by strong bands of copper; their width is 11 c.m.; their horizontal polar surfaces are directed towards the base at 12 c.m. distance; their thickness is 20 m.m.; they receive a cubic contact of soft iron which weighs 13 kilos. The carrying force F, measured after the first withdrawal, is always greater than F_1 which is the permanent force; the difference increases least rapidly from 40 to 45 plates:—

n.	F.	F_1.	$F - F_1$.
20	175	154	21 kilos.
30	316	280	46 ,,
40	460	376	84 ,,
45	558	460	98 ,,
50	600	475	125 ,,
55	680	495	185 ,,

At this moment there appears a notable quantity of free magnetism upon the extremities of the magnet. From 40 to 55, the force F increases, but F_1 remains nearly constant.

On a Continuous Electro-Diapason.—By M. E. Mercadier.—Having had occasion to study the electric phenomena produced during very short times in telegraphic apparatus, I have been led to seek the possibility of constructing an apparatus susceptible: (1) of dividing time into very small and equal fractions; (2) of producing these very small durations in a continuous manner; and (3) of easily registering these fractions of time. A solution of this problem, long since applied, consists in the use of two tuning-forks, A and B, of which one B makes a number of vibrations equal to that of the other or a multiple. The fork A is arranged as a Froment's electric trembler, with a mercury contact as in Foucault's interrupter. Facing each branch of the fork B is an electro-magnet, in which a current passes interrupted at every instant, which circulates in the electro-magnet of A in entering on its movement. There results on the branches of B a series of rapid synchronous attractions. A style fixed to this diapason can write these vibrations. This apparatus is complex, and prevents several inconveniences. We may avoid these inconveniences by the use of the following apparatus. The apparatus advised consists of a single fork screwed into a thick board. A small electro-magnet of feeble resistance is fixed so as to face one of the branches of the fork, which carries a platinum wire about one centimetre in length, to serve as an interrupting style. To the other branch is fixed a steel wire of 0·3 m.m. diameter, serving to register the vibrations. A platinum plate is placed between the two branches of the fork facing the platinum wire, and making contact with it when the two branches approach. Finally, the positive pole of a battery is put into communication with the interrupting plate and the negative with the interrupting style, including in the circuit the tie of the fork and the wire of the electro-magnet. I have thus obtained with forks of 128, 256,512 vibrations per second, and a cylinder of only 15 c.m. diameter waves of 4 and 5 m.m.

Reply to an Observation by M. Raynaud on the Conditions of the Maximum Resistance of Galvanometers.—By M. du Moncel.—This will be found in another page of the journal.

Notes and Queries.

Cleaning Silver Articles.

The Boston *Journal of Chemistry* gives an interesting account of the way in which the natives of East India clean silver articles. The East Indian Jewellers never touch silver-ware with any abrasive substance. For articles even the most delicate, the method of cleaning is to cut some juicy lemons in slices, with these rub any large silver or plated article briskly, and leave it hidden by the slices in a pan for a few hours. The articles are then to be removed, rinsed in two or three waters, and consigned to a small pan of nearly boiling soap-suds, well stirred about, taken out, again brushed, rinsed, and finally dried on a metal plate over hot water, finishing the process by a little rub of wash leather (if smooth work). For very old, or corroded silver, dip the article, with a slow stirring motion, in a rather weak solution of cyanide of potassium; but this process requires care and practice, as it is by dissolving of the dirty silver you obtain the effect. Green tamarind pods (oxalate of potash) are greater detergents of gold and silver articles than lemons, and are much more employed by the artisan for removal of oxides and fire-marks.

Stopping-Off.

I beg to offer my mite in answer to a query in reference to a medium, or varnish, for the stopping-off, as it is termed by gilders, of certain parts of the work, say the pattern not required to be gilded. In a work* I have by me I find the following:—"Now it frequently happens that, in the objects to be gilt, there are portions that must not be gilt, and which consequently must be covered with a varnish that prevents the gold being deposited upon them. The composition, and the mode of the application of this varnish, are not without importance, especially when the object in view is to preserve the steel pinions, which carry the brass wheels of watch movements, and which must also be subjected to friction in the process of graining, which it is necessary that this varnish should resist, seeing that it otherwise cannot be preserved from it. One of the best varnishes consists of a mixture of 3 parts resin, with 1 part yellow wax, 1 of red oxide of iron, and 2 or 3 of betuline, a resinous substance obtained by treating the bark of the birch by alcohol, and which possesses the advantage of not being soluble in alkalies. The application of these varnishes likewise permits of the production upon the same articles of gildings of different colours, and even of applying, at pleasure, gold and silver upon fixed places, in the dead or brilliant state, and thus to construct charming works in gilding and plating. I may add that the varnish is dissolved off in hot olive oil. I have tried many times to procure the betuline, but could not."—Electro.

[Betuline may be procured.—Ed.]

Locking Apparatus for Railways.—We are requested to state that the original invention of "locking apparatus" was patented by Mr. Saxby in 1856, four years prior to the patent of improvement taken out by Mr. Chambers, and referred to in our report of the last meeting of the Society of Telegraph Engineers.

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* "Treatise on Electricity." By Aug. De La Rive. Translated by Charles V. Walker, F.R.S., F.R.A.S. Volume III. Longmans and Co. 1858.

City and Commercial Notes.

SPEAKING of telegraph securities in his Monthly Circular, dated June 6, Mr. William Abbott, of 10, Tokenhouse Yard and the Stock Exchange, says:—"I am glad to be able to state that the Directors of the Atlantic lines are, in response to the urgent desires of the great body of the proprietors, vigorously pushing on the necessary measures for completing the fusion of the several companies, and I have no doubt that, in a few weeks, the western lines will have become merged into one undertaking of sufficient strength, not merely to prevent a waste of telegraphic capital, such as has been contemplated by recent competitive schemes, but to extend the principle of cheaper messages to America on a scale such as will astonish the promoters of an undertaking which was incubated merely to destroy capital already invested in Atlantic business. The Newfoundland Company has seemed to offer a special mark to the speculative cliques who have worn threadbare the supposed pre-emption power of the Government. One point, however, they cannot overcome, viz., the exclusive rights possessed by the Company to land cables on the shores of Newfoundland for the next thirty years. In the one instance of the new French Cable, the chairman has shown clearly that half a million has been saved to the associated Atlantic lines by the existence of this very right. Supposing that the development of traffic will require a new cable to be laid to Newfoundland every five years, this would represent to the Amalgamated Company a saving, for the rest of their term, of no less than three millions sterling. Another important feature of the month has been the picking up and repair of the lost cable between Florida and Cuba. This, with the submersion of the new line just completed, gives a duplicate cable for the valuable traffic of the West Indies. I am glad to learn that the board of the West India and Panama Company is now about to be strengthened by the addition of two most influential members. With reference to the Eastern lines, there is still a marked difference in the quotation for the shares of the two Companies, the interruption to the Singapore section having caused a temporary depression in the Eastern. The latter shares are relatively the cheapest at the moment, as after next distribution the dividends will no doubt be equal. The difference in the next dividend will not exceed 2s. per share in favour of Easterns, while the difference in the quotation now amounts to 12s. 6d. per share. This anomaly is due to the supposition that all the Extension traffic must first pass over the Eastern lines. It should, however, be remembered that the Extension system enjoys a rich traffic of its own, between China, the Dutch settlements, and Australia, undiluted by any competition, and which more than neutralises the tribute paid to the Eastern undertaking upon the through traffic."

With reference to the Amalgamation of the Atlantic Telegraphs, a bill was filed by a dissatisfied shareholder against the Anglo-American Telegraph Company, alleging that it was *ultra vires* for that company to purchase the French Atlantic and Newfoundland Telegraph Companies. We are, however, glad to record the withdrawal of this bill. The action came on on Thursday, the 5th inst., before the Lord Chancellor, sitting for the Master of the Rolls, when the Solicitor-General said notice had been received that the plaintiff did not intend to proceed with his motion or cause. Costs were granted against the plaintiff in the case.

The second ordinary general meeting was held on the 6th inst. of the shareholders of the German Union Telegraph Company, Limited. The chairman, Sir James Anderson, said that Count Reichenbach, one of the directors, attended the general meeting of the Berlin Company to endeavour to obtain various modifications in the statutes and management of that Company. Although Count Reichenbach, from various causes, did not succeed with regard to the greater number of the alterations required, yet his exertions had led to the reduction of the expenses of management to the extent of £800 or £900 per annum. The balance-sheet and accounts showed a divisible balance of £5,079 7s. 2d., of which the directors have, in anticipation of the present meeting, distributed £5,014 7s., being at the rate of 5s. 6d. per share, leaving £65 0s. 2d. to be carried forward to the next account. The directors have received from shareholders in the German Union Telegraph Company of Berlin 9092 shares in that Company, and have issued 18,234 fully paid shares in this Company, including 50 shares issued for cash. As the total number of shares of the Berlin Company is 11,000, it follows that there are 1908 of those shares at present held by parties other than this Company. The directors's report was adopted, and a very cordial vote of thanks was passed to the chairman and directors for the great care with which they have managed the affairs of the Company.

It is announced that "the circulars to the shareholders respectively of the British-Indian Extension Telegraph Company, Limited, the China Submarine Telegraph Company, Limited, and the British-Australian Telegraph Company, Limited and Reduced, requesting them to take up the shares in the Eastern Extension, Australasia, and China Telegraph Company, Limited, to which they are respectively entitled, were this day issued, and that the transfer books of the Eastern Extension, Australasia, and China Telegraph Company have been opened, and the transfers will be registered immediately after the share certificates in the Eastern Extension, Australasia, and China Telegraph Company have been issued to the shareholders in the three Companies first named."

The ordinary meeting of the shareholders was held on the 5th inst. of the Montevidean and Brazilian Telegraph Company, when it was stated that the cable has been inspected and found in a very efficient state, and it is expected that it will be laid and be in working order by the beginning or middle of August next. It is believed that, as soon as the cable is laid, a large traffic will at once pass over the line.

It is also announced that at a meeting of the directors of the Eastern Extension, Australasia, and China Telegraph Company, Limited, held on June 5, an interim dividend of 3s. per share for the quarter ending March 31, 1873, was declared, payable on the 15th July.

The directors of the Eastern Telegraph Company have resolved to recommend to the shareholders the payment of a final dividend of 5s. per share, making, with previous payments, 7 per cent for the year ending March 31, 1873. The dividend will be payable immediately after the half-yearly meeting, which will be held on the 15th July next.

The traffic receipts of this Company for the month of May, 1873, amounted to £29,852, against £31,707 in the corresponding period of 1872. The deficiency is owing to the recent interruption in the *Extension* Company's line.

A special meeting of the Sociéte du Cable Transatlantique Francais, Limited, took place on the 13th inst., to confirm resolutions already passed.

It is notified that the creditors of the Great Western Telegraph Company are to send in their claims to Mr. John Weise, the liquidator of the Company, at his offices, No. 16, Tokenhouse Yard, on or before the 24th inst.

The Danish Government has granted a concession to the Great Northern Telegraph Company to establish submarine telegraphic communication between West Jutland, or Fanoe, and France, and between East Jutland and Sweden.

The total traffic receipts of the Great Northern Telegraph Company have been, during May, 1873, 304,669 francs, and in corresponding period of 1872, 208,851 francs. On the European lines, in 1873, 142,249 francs; in 1872, 114,366 francs. On the China and Japan lines, in 1873, 162,420 francs; in 1872, 94,485 francs.

A telegram from St. John's announces that the Newfoundland Government has notified the New York, Newfoundland, and London Telegraph Company that it will abandon its pre-emptive right if the Company will abandon the monopoly of landing cables on Newfoundland. If the Company does not assent to the proposition, then the Government will exercise its right of pre-emption.—*Times*.

NEW TELEGRAPH COMPANIES.

The following new Companies have been registered in accordance with the provisions of the Limited Liability Act:—

The Western and Brazilian Telegraph Company, Limited. Capital £1,350,000, in £20 shares.—This undertaking is formed for the purpose of establishing or acquiring Submarine Telegraphs along the Continent of South America. The subscribers (who take one share each) are—John Heugh, 103, Cannon Street; Alfred Seymour, M.P., 47, Eaton Square; H. S. Erichsen, 7, Great Winchester Street; J. M. Dunlop, Windermere; Julius Beer, Bank Buildings, Lothbury; E. W. Barnett, 3, Westminster Chambers; and Nathaniel Buckley, M.P., Ashton-under-Lyne.

The Central America Telegraph Company, Limited. Capital £350,000.—This Company will construct a Telegraph from Para in Brazil, to other parts of the South American Continent or the West Indies. The subscribers to this project are the same as in the previous one.

TELEGRAPH SHARE LIST.

Amount per Share.	Name of Company.	Amount paid up.	Closing Quotations.
£		£	June 12.
Stock	Anglo-American (Limited)	100	141—143
10	Brazilian Submarine..	3	1½—1 dis.
10	Cuba	All	9½—10
10	Eastern Telegraph Co.	All	9½—9¾
10	Ditto Extension	All	— —
10	Great Northern	All	10 —10¾
20	Great Western	13	— —
25	Indo-European	All	15—17
10	Mediterranean Extension (Limited)	All	5½—6
20	New York, Newfoundland, and London	20	21¾—22¼
8	Reuter's	All	10¼—10¾
20	Société Transatlantique Francaise..	All	33—33½
Stock	Submarine	100	230—240
Cert.	Ditto Cables Trust	100	109—114
10	West India and Panama	All	7¼—7¾
10	Hooper's Telegraph Works	All	13¼—13¾
50	India-Rubber and Gutta Percha ..	All	35—37
12	Telegraph Construction	All	33¾—34¼
Cert.	Ditto Ditto 3 years' Bonds	100	103—105
20	Direct United States Cable	81	2—1 dis.
1000 dls.	West Un. U.S. 7 per cent 1st M.B.	All	91—93

Post Office Telegraphs.—The following statement shows the total number of messages forwarded from postal telegraph stations in the United Kingdom during the week ended the 7th of June, 1873 (the Whitsuntide holidays), and during the corresponding week of 1872:—Week ended June 7, 1873, 304,539; June 8, 1872, 286,687; increase in the week of 1873 on that of 1872, 17,852.

Franklin's Battery.—Among the philosophical apparatus at Dartmouth (U. S.) is a battery of thirty-six cells, which was used by Franklin in his celebrated experiments. It has quite a history, having been sent to America by Dr. Priestly at the time of the Irish riots. After Franklin owned it, it fell into the hands of Dr. Prince, of Salem, and finally was obtained by the grandfather of Prof. Young, who at present has it in his possession.

Electrical Apparatus.—Letters Patent have been awarded to Mr. Stanley, of Holborn, for improvements in electrical apparatus, stated in the Specification to consist in the construction of the class of electric batteries which generate dynamic electricity so as to render them more portable, by making the cell (jar or bottle) which contains the voltaic couple of about double the internal length of the active portion of the plates, which will be generally of zinc and carbon. The plates, if they extend beyond the half the interior, must be insulated from action of the exciting fluid, or they may be half length, and be fixed either in the top or the bottom of the cell. The purpose is that the battery may be turned upside down, and in such position there will be no electrical action, as the fluid (or fluids in case of an inner pot) will not then touch the plates. The batteries are sealed over with some elastic substance, in such a manner that the fluid cannot escape. Within the sealing is a valve, so fixed that the internal gases may escape at less pressure than would break the cell or the sealing: this valve consists of a tube with a piece of sheet india-rubber tied over it as an air-pump valve; the novelty being the application of this valve to a sealed battery cell. A further arrangement is provided for connection of batteries with apparatus to form a portable bell. For this a box is divided into two parts, one to contain the battery, which is closed, and the other to contain the electrical bell and a roller to roll up the conducting wires with touch. This part has a door which closes the apparatus when out of use, and a handle above for carrying the whole. Mr. Stanley claims as novelties a long cell, half active; a sealed cell with a peculiar valve; a water-tight cap for cells; a closed receptacle with solid terminals for cells; a bell rendered portable; a portable coil, set in motion by reversing the apparatus; and a double receptacle for battery—the last three being novelties as instances of application of the previous parts.

New Telegraph Ship.—In the *Telegraphic Journal* for February 15, we announced that the directors of Hooper's Telegraph Works had ordered a steamer to be built expressly for the purpose of reducing the expense and lessening the risk of submerging telegraph cables. On Wednesday, the 11th inst., a party of scientific gentlemen assembled at Millwall Docks to inspect this new vessel. She is 350 feet in length, 55 feet beam, and 36 feet in depth, and of 5000 tons gross register, with engines of 400 nominal horse-power working up to 2000, and realises, though not intended for speed, 10½ knots an hour. Being the first vessel ever constructed entirely for telegraphic purposes, her tanks, which are only three in number—huge cylinders, 30 feet deep and 53 feet wide—so far from being a source of weakness, really strengthen the hull; while the paying-out machinery and the appliances for picking up a lost or damaged cable embrace every improvement which experience up to the present time has suggested. The vessel is now taking in 1500 miles of cable directly from the Hooper works at Millwall, belonging to the Western Telegraph Company, which is about to lay 2500 miles of cable along the east coast of South America. The work will be performed in three sections, the first, that which is now about to be despatched on board the *Hooper*, being laid from Pernambuco to Rio de Janeiro, the second from Pernambuco to St. Thomas's, and the third from Rio to Monte Video, taking in all the intervening South American ports. After inspecting the works of Hooper's Telegraph Company, the party adjourned to the vessel—a noble, though somewhat unsightly, craft—much interest being felt in the perfect electrical testing cabin, fitted up at the suggestion of Sir Wm. Thomson, who, with Mr. Latimer Clark, represented science on the occasion, and showed the means by which signalling and testing for insulation can be carried on at the same time.